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PLAN AND PROGRAM

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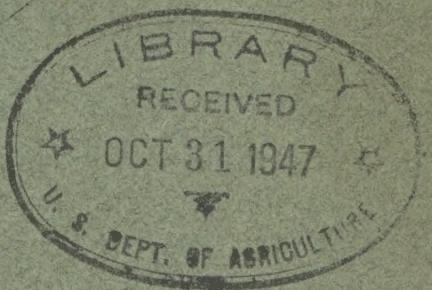
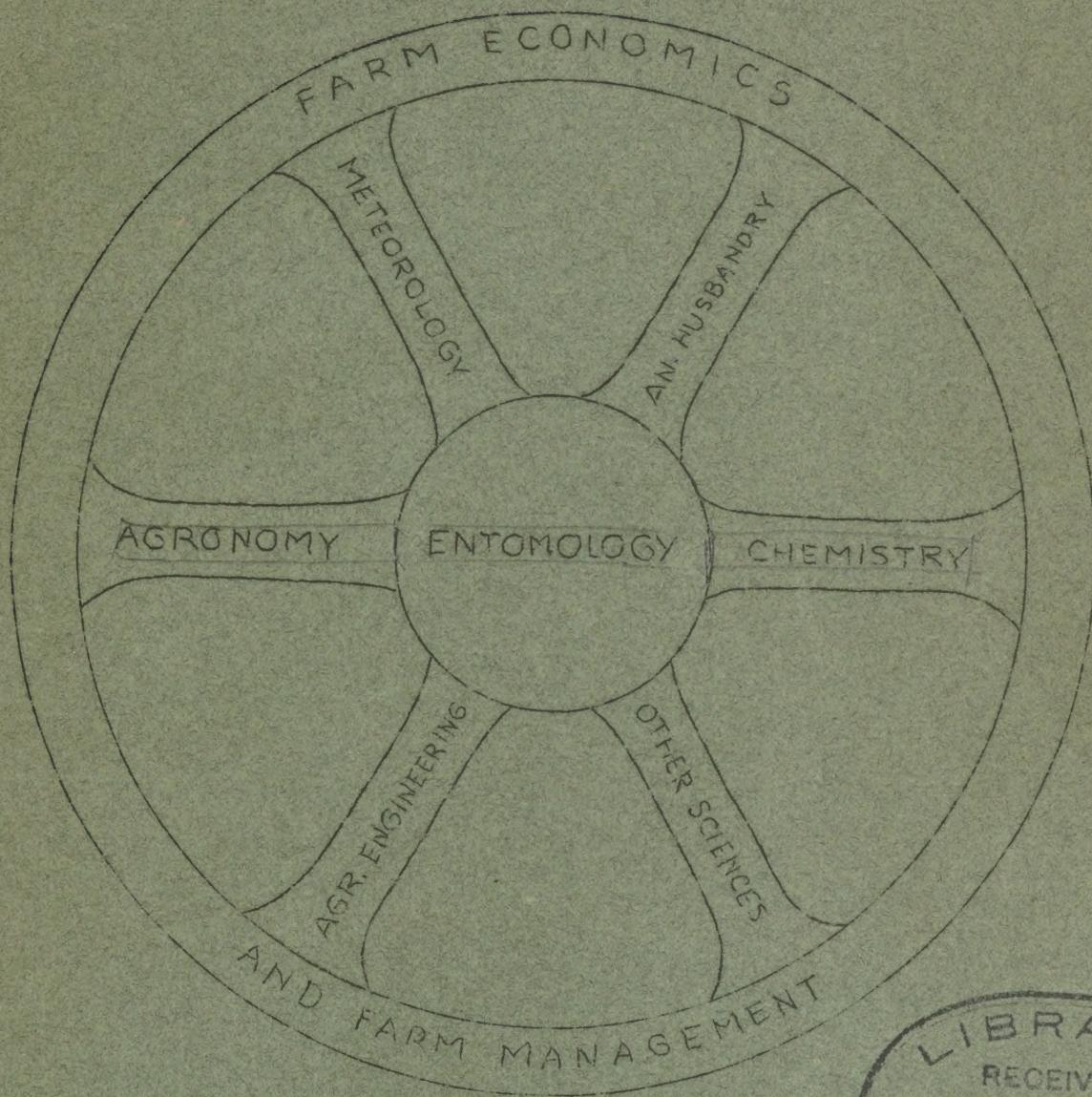
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U. S. Department of Agriculture

European Corn Borer Research

1928

Reserve



U. S. Department of Agriculture

Washington, D. C.

January 3, 1928

PROPOSED PROGRAM AND PLAN

OF

EUROPEAN CORN BORER INVESTIGATIONS

1928

- CONTENTS -

	Page
Entomology, D. J. Caffrey	1
Agricultural Engineering, S. H. McCrory	p. 20
Agronomy, Cereal Crops, C. R. Ball	p. 23
Forage Crops, A. J. Pieters	p. 25
Animal Husbandry, E. W. Sheets	p. 26
Chemistry and Soils, Chemistry, R. C. Roark	p. 28
Soils, C. F. Marbut	p. 28
Agricultural Economics, H. R. Tolley	p. 30

PROPOSED

PROGRAM AND PLAN

OF

EUROPEAN CORN BORER INVESTIGATIONS

BUREAU OF ENTOMOLOGY

1928*

	<u>Pages</u>
I - Distribution	1
II - Control	1-7
III - Life-History, Seasonal Occurrence, & Habits.....	7-11
IV - Dispersion	11-12
V - Host Plants	12-13
VI - Investigations in Europe	13
VII - Investigations in the Orient	15
VIII - Natural Enemies	15-17
IX - Disease	17
X - Miscellaneous	17-21

Arlington, Mass.

Silver Creek, N. Y.

Sandusky, Ohio

Toledo, Ohio

Monroe, Michigan

Hyeres, France

* Supersedes and supplements "Programs" of
1919 - 1927 inclusive.

January 1, 1928.

I - Distribution.

A - Determination of the actual distribution of the corn borer in the United States.

1 - Identification of material sent in by Mr. Worthley's field scouts, quarantine inspectors and other field workers. Includes material from miscellaneous sources. Adults reared to confirm larval determination when material is submitted from new widely separated areas-or from new host plants. In cooperation with United States National Museum.

II - Control

A - Burning infested material (in cooperation with agricultural engineers).

1 - By machine.

2 - By various farm methods.

a - Poling, cutting, raking etc. Involves tests of various types of rakes.

(1) - Effectiveness of various burning methods checked by computing percentage of living borers remaining in debris; compared to original borer population.

3 - Heating and combustion tests.

Note: Special data required for most effective use of large and small field burners.

a - Free larvae.

(1) - Determine time period and temperature required to kill free larvae under various conditions and changes of temperature, humidity and contact moisture. The time period objective, under practical field conditions is two seconds.

b - Larvae in cornstalks.

(1) - Same as A-3- a-(1).

c - Special tests to determine possible variation in larval mortality from burning, in different portions of the corn plant; when subjected to sharp fluctuations in temperature or contact moisture; succulent plants compared to post-mature plants containing various percentages of moisture; under different conditions of heat dilution caused by high winds or otherwise.

d - Construct a melting "plug" or "cone" designed to be inserted in cornstalks during field burning operations and to melt or otherwise verify when effective killing temperatures have been attained in center of stalks - as determined under a-b and c.

4 - Continuation of experimental development and testing of large and small field burners under corn borer conditions.

B - Feeding infested material to livestock (in cooperation with agricultural engineers).

1 - Direct from field 2 - As ensilage; 3 - Ground; 4 - From cutting box; 5 - From husking machines.

a - Effectiveness of each method under various conditions of treated material. Also with machines adjusted for various speeds, length of cut etc.

(1) - Measure effectiveness by detailed examination of definite unit of material, the larval expectancy previously computed.

C - Plowing infested material (in cooperation with agricultural engineers.)

1 - Experimental studies.

a - Determination of the influences responsible for migration of larvae to soil surface when plowed under, in single generation area.

b - Study of adult emergence from cleanly plowed fields.

(1) - Erection of cage over acre-plot plowed cleanly in fall just prior to emergence of adults.

(2) - Same over spring plowed acre-plot.

c - Critical study and comparison of effectiveness of different types and sizes of plows, operated at varying speeds and with varying adjustments, attachments and accessories. Involves tests in different soil types.

(1) - Measure effectiveness by amount of debris left on soil surface in unit area.

d - Determine duration of period necessary for disintegration of corn-stalks when plowed under in soils of various common types. Applies to status of old corn residues as a shelter for migrating borers when again brought to soil surface by plowing, or other cultural practices.

2 - Field studies.

a - Effectiveness of various plowing methods checked by computing percentage of living borers surviving in debris; compared to original borer population, in stalk and stubble fields.

(1) Involves use of data assembled in large-scale field surveys prior to clean-up operations.

(2) - Continuation of field studies to determine status of field border or fence row as shelter for migrating larvae.

D - Varietal and seasonal planting (in cooperation with agronomists).

1 - Experimental studies.

a - Continuation of cooperative experimental planting projects with Bureau of Plant Industry, Mass. Agricultural Experiment Station and Illinois Agricultural Experiment Station.

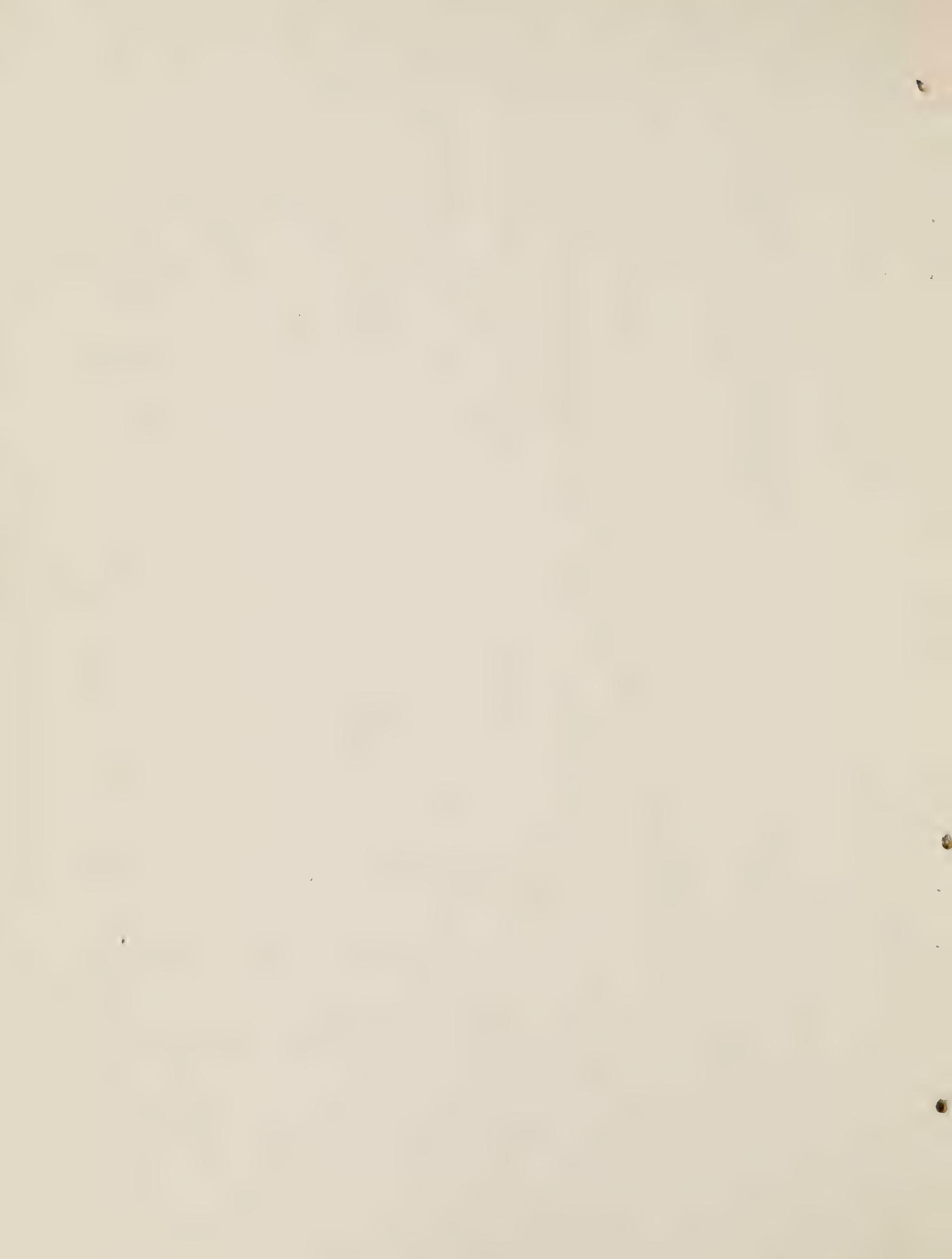
(1) - Involves planting of standard varieties and strains of corn on successive dates.

(2) - Corn breeding to develop sorts which are tolerant to corn borer injury and which may be planted late and yet yield profitable returns.

(3) - Comparative tolerance to severe corn borer injury of corn varieties or strains infected by various common corn diseases, notably Diplodia and Gibberella, and the same varieties or strains when disease-free or nearly disease-free.

2 - Field observations.

a - Analysis of effect of seasonal and varietal planting as shown by data secured in infestation surveys of commercial fields.



3 - Phenological studies on the development of common trees or shrubs, to correlate plant development with the optimum time of planting to avoid severe injury by the insect and with the seasonal occurrence of the insect. A continuation of long time project. Choice of plants for observation and phases recorded to be same as in previous years.

a - Development of plant to be correlated with curves of temperature and precipitation.

E - Status of host plants other than corn.

1 - Experimental studies in the Middle West.

a - Experimental plats of cotton, millet, the more important sorghums, oats, barley, beets, beans, celery, potato, tomato, sunflower, soy bean, cowpea, alfalfa, clover, sweet clover, buckwheat, dahlia, gladiolus, chrysanthemum, cosmos, canna, geranium, golden glow, hollyhock, calendula and zinnia.

(1) - Determine status of each as a true food plant or as a shelter plant.

(2) - Study effect of isolating corn borer, in cages, on several of the more susceptible plants of the above group, plus the more susceptible weeds for a long period of years. To determine possible existence of host plant races, the effect of such isolation upon the insect and particularly whether such plants will support the corn borer indefinitely in the absence of corn.

2 - Experimental studies in New England.

a - Same as E-1-a, including only those plants upon which adequate information has not already been secured.

b - Study of plants which may be repellent or toxic to the borer.

3 - Field observations.

a - Check results secured under E-1 and E-2 with commercial plantings.

b - Study of infestation in weeds and large-stemmed grasses.

(1) - Determine status of each as a true food plant or as a shelter plant. Note distance from growing corn or infested corn remnants.

F - Special field machinery (in cooperation with agricultural engineers).

1 - Experimental development and field tests of special field machinery to aid in field clean-up measures.

(1) - Low cutting devices; (2) - Stubble pulverizers; (3) - Various combines.

G - Disposal of infested material in manure pile, barnyard, feedlot etc.

1 - Animal manure - Mortality of larvae contained in corn, or other plant remnants when incorporated in animal manure.

a - Entire stalks. b - Portions of stalks. c - Cobs. d - Partially buried. e - Entirely buried. f - Under varying conditions of moisture. g - Under various methods of handling. h - From various animals.

(1) - Experimental studies. Duplication of various barnyard conditions with detailed study of fate of larvae in infested material when larval expectancy is known.



(2) - Field observations. Numerous examinations of corn remnants, and other plant material, under farm conditions, noting points detailed in G-1-a to h. Conducted in spring just prior to pupation.

2 - Artificial manure. Continuation of studies with alkaline nitrogenous fertilizer, as in G-1-a to h.

H - Insecticides.

1 - Experimental tests.

a - Materials:-

(1) - Arsenicals (examples).

- (11) - Hydrogen lead arsenate.
- (22) - Coated " "
- (33) - Colloidal " "
- (44) - Basic " "
- (55) - Calcium arsenate
- (66) - Etc.

(2) - Emulsified extracts (examples).

- (11) - Pyrethrum.
- (22) - Derris.
- (33) - Pyridine.
- (44) - Etc.

(3) - Oil emulsions (examples)

- (11) - Paraffin oils.
- (22) - Fish oils.
- (33) - Etc.

(4) - Silico-fluorides (examples)

- (11) - Sodium silico-fluoride
- (22) - Potassium " "
- (33) - Calcium " "
- (44) - Aluminum " "
- (55) - Etc.

(5) - Carriers, emulsifiers, adhesives, colloids, etc, employed in preparation and application of insecticidal materials.

b - Tested for:-

- (1) - Toxicity
- (2) - Adhesiveness.
- (3) - Number applications required.
- (4) - Plant tolerance.
- (5) - Compatible combinations.
- (6) - Cost of application:-
 - (11) - For small areas.
 - (22) - Large scale.

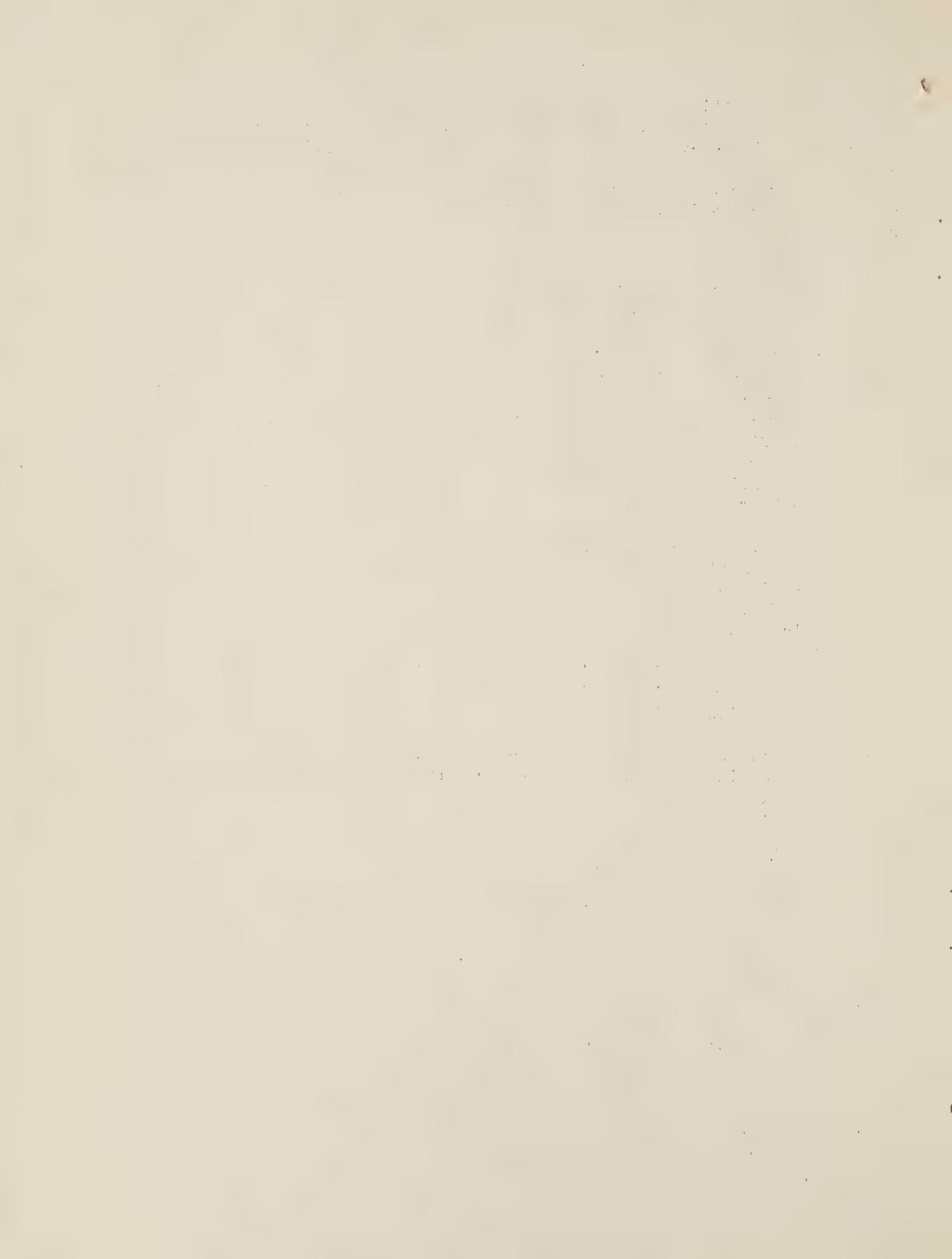
c - Application.

(1) - Plots:-

- (11) - Tolerance test plots.
- (22) - Toxicity " "
- (33) - Commercial field test plots.
- (44) - Alternate check plots.
- (55) - Plots in triplicate and distributed over field.

(2) - Methods:-

- (11) - Compressed-air sprayers.
- (22) - Rotary fan dusters



- (33) - Bellows dusters.
- (44) - Power sprayer.
- (55) - Power duster
- (66) - Air plane dusting.
- (3) - Supplementary adhesives.
 - (11) - Casein.
 - (22) - Fish oil soap.
 - (33) - Paraffin oil emulsions.
- d - Schedule of applications.
 - (1) - Number applications necessary.
 - (2) - Application with reference to seasonal development of:
 - (11) - Corn plant.
 - (22) - European corn-borer.
 - (3) - Relation of application to climatic conditions.
- 2 - Laboratory investigations:-
 - a - Chemical tests
 - (1) - Exact formulae of material employed.
 - (2) - Deterioration:-
 - (11) - In storage.
 - (22) - On host plant.
 - (3) - Residues.
 - (11) - Retention of lethal capacity.
 - (22) - Toxicity to human species.
 - (33) - Toxicity to domestic stock.
 - (4) - Compatible combinations.
 - (5) - Value of emulsifying agents.
 - (6) - Cause of intolerance.
 - b - Biological tests.
 - (1) - Ovicidal value.
 - (2) - Larvicidal capacity.
 - (11) - Specific effect.
 - (22) - Rapidity of action.
 - (33) - Quantity required.
 - (44) - Mortality.
 - c - Relation of insecticides to feeding habits.
 - (1) - Distribution of insecticide.
 - (2) - Distribution of feeding punctures.
 - (3) - Materials ingested.
 - (4) - Materials rejected.
 - (5) - Age of larva at first ingestion of plant material.
 - (6) - Physiology of digestion in 1st instar larvae.
 - (7) - Importance of cannibalism in feeding habits.
 - (8) - Nature of tropic-response complex governing feeding reaction.
 - (11) - Hygro-thermal stimulus.
 - (22) - Phototropic stimulus.
 - (33) - Chemotropic stimulus.
 - (44) - Thigmotropic stimulus.
 - (55) - Geotropic stimulus.
 - (9) - Operation of response complex in relation to presence of insecticides.



(10) - Relation of insecticidal agents to tunneling habit.

5 - Trial field tests.

a - Efficiency with respect to plant tolerance.

b - Efficiency with respect to cost of application.

4 - Commercial field tests.

a - Efficiency of method and material.

b - Cost of method and material.

c - Profit under commercial conditions.

d - Relation of insecticides to respiratory requirements.

(1) - Distribution of insecticide.

(2) - Source of metabolic oxygen.

(3) - Method of oxygen absorption.

(4) - Specific effect of "contact insecticides".

I - Storage of cornstalks.

1. - Experimental studies.

a - A continuation of studies upon results of storing cornstalks under various conditions of exposure to temperature, and moisture, on various dates. Adult emergence, oviposition and percentage of larval establishment determined.

2 - Field observations. Checking above, by examination of cornstalks, corncobs, etc., stored under various farm conditions.

3 - Survival of larvae and emergence of adults from baled cornstalks, when such stalks are stored under various conditions of exposure to temperature and moisture.

a - Entire cornstalks. b - Shredded material. c - Processed by various other methods.

Note: These studies designed to anticipate needed information relative to storage of cornstalks intended for commercial utilization.

J - Trap Crops (Incidental)

1 - Field observations in Middle West.

a - Continuation of existing projects to check results of trap crop plantings, where a sequence of planting occurs from early to late. Analyze results of annual infestation survey and experimental plot data on same basis.

2 - Field observations in New England.

a - Same as J-1-a, with proper allowance of 2 generation conditions.

K - Miscellaneous control phases.

1 - Comparative mortality, to adult emergence, in trash on soil surface in small area simulating various cultural conditions.

a - Area where trash is shaded by oats.

b - " " " " " corn.

c - " lacking shade of any kind.

(1) - Temperature readings on soil surface and within trash during periods of high temperature and dessicating winds.

2 - Emergence of adults from clods on soil surface.

3 - Progressive migration of plowed under larvae to soil surface in spring.

4 - Standard debris examinations, just prior to emergence of

adults, classified according to control practices employed.

5 -Comparative infestation in field and sweet corn in relation to seasonal planting.

6- Proposed screening of 5-acre unit "farms" during period of adult occurrence, such unit "farms" to be given various cultural control and other control practices over a period of years. Object to determine comparative effectiveness of different practices, to serve as demonstrations and to obtain data relative to economic status of the insect.

a - No treatment designed to control borer.

b - Stalks poled, raked, burned.

c - Stalks plowed under.

d - Stalks cut low, field disked.

e - High stubble disked.

f - Stalks disked.

g - Control confined to parasites.

h - Corn planted late.

III - Life History, Seasonal Occurrence And Habits.

A - Assemble following data re Life History based upon field and laboratory observations (listed by seasonal occurrence).

Note: This section confined practically to Monroe, Michigan laboratory, since sufficient life-history data have been secured at the other laboratories.

1 - Duration of pupal period.

2 - " " adult "

3 - " " egg "

4 - " " larval "

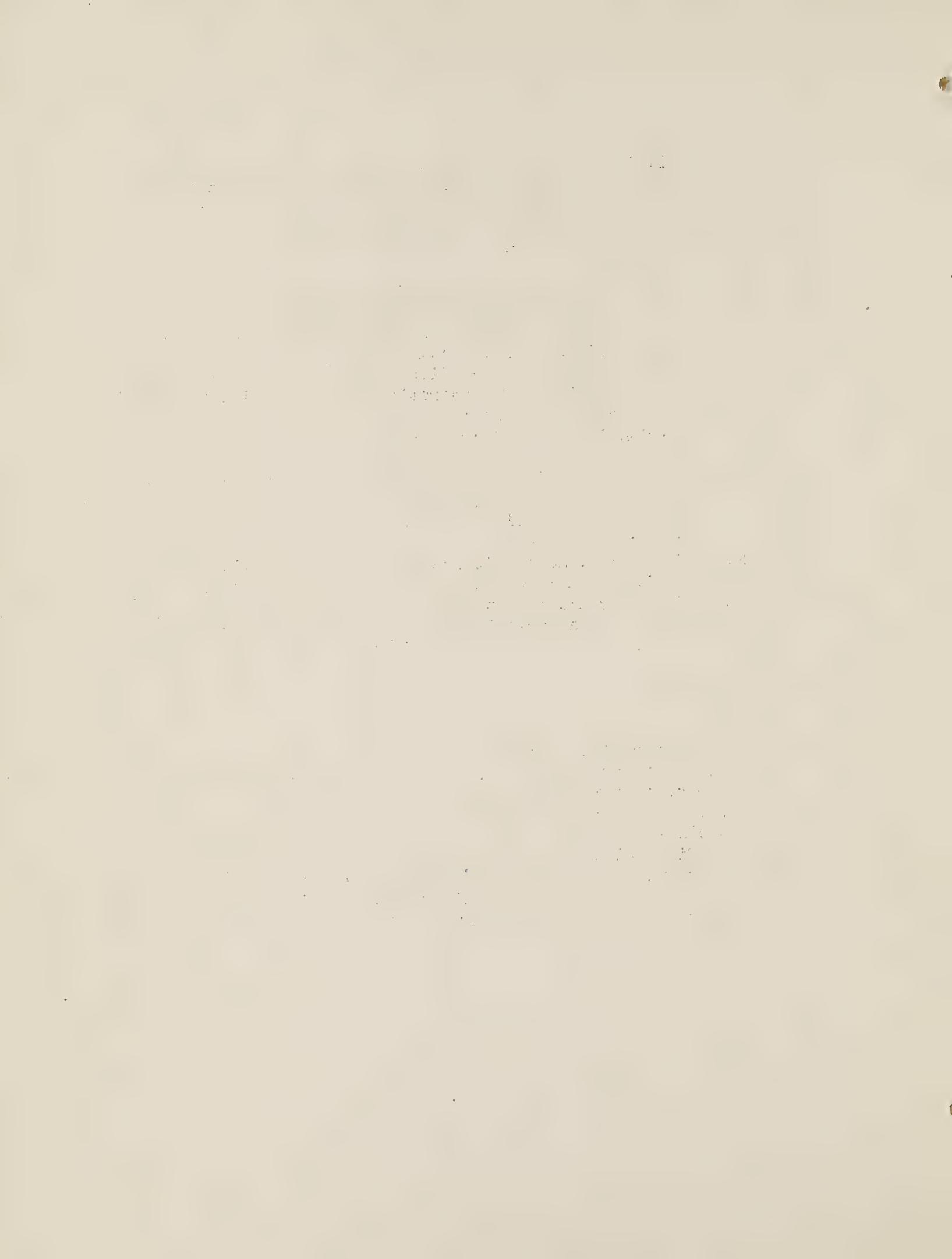
B - Assemble following data re Seasonal Occurrence based upon field and laboratory observations. With special reference to information needed for control, quarantine and scouting operations.



- 1 - In the Middle West (one generation).
 - a - Continuation of studies to secure data relative to first occurrence, progress and last occurrence of each stage in field, under various typical conditions, and in cages.
 - b - Continuation of observations to determine possible development of second generation.
 - c - Phenological studies as detailed under II-D-3.
 - d - Study of influences responsible for variations in seasonal cycle (number of generations) within the World distribution of the insect.
 - (1) - Biological, meteorological, ecological studies in U. S.
 - (a) - Continuation of studies in transferring single generation material to two generation areas and vice versa. Rearing of such material in large field cages for an extended period.
 - (b) - Continuation of cross-breeding and rearing (in large field cages) of single and double generation sexes.
 - (c) - Meteorological and ecological studies reported upon previously and additional manuscripts and data awaiting publication. Possible continuation of such studies as promise practical results.
 - (2) - Biological, meteorological, ecological studies in Europe.
 - (a) - Detailed in section devoted to investigations in Europe.
 - 2 - Seasonal Occurrence in New England (two generation).
 - a - Same procedure as detailed in Middle West with proper allowance for the presence of two generations.

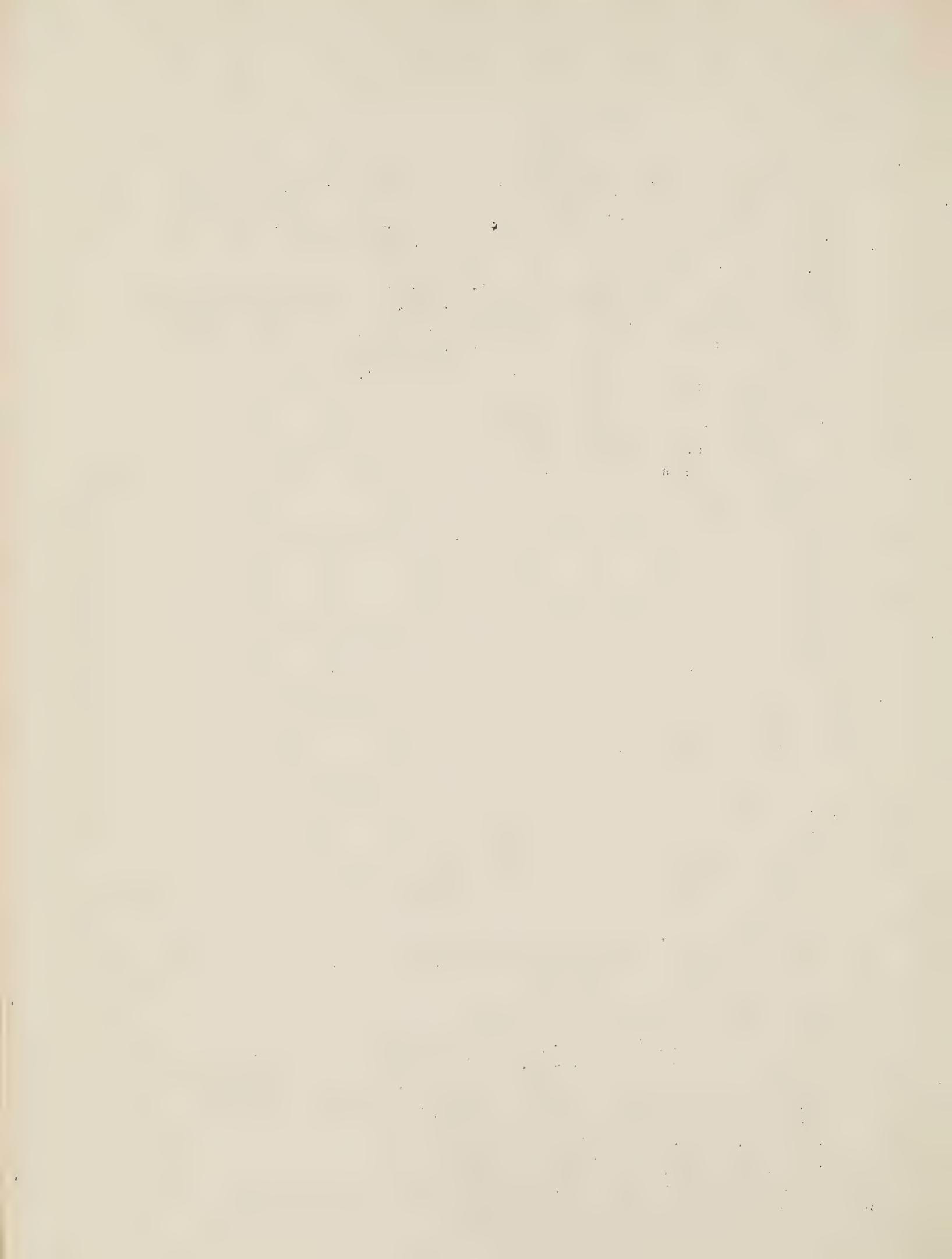
C - Habits (Larvae)

- 1 - Migration
 - a - From material plowed under.
 - b - From or to growing plants, or plants in natural position.
 - c - From or to corn in shock.
 - d - From or to corn, or other plants, cut and piled.
 - e - To other parts of same host.
 - (1) - Dispersion of young larvae after hatching from egg cluster.
 - (2) - Continuation of studies relative to migration of established larvae to lower part of plant during late season, with special reference to its application to low-cutting operations, pertaining to control.



- (3) - Continuation of studies relative to conditions favorable for larval migration to ears.
- f - Influence of natural or artificial barriers in preventing or limiting migration.
- g - Daily and seasonal period of greatest migration.
- h - Meteorological influences affecting migration.
- i - Migration to plants and inanimate objects for shelter.
- j - Migration, mortality and establishment of newly hatched larvae.
(Detailed under C-3-c).
- k - Determine percentage of larvae migrating to definitely known lineal feet of cornstalks placed along field border of heavily infested sweet corn field plowed under in late summer.
- 2 - Hibernation.
- a - In normal locations within host plant.
- b - In artificial locations within shelter plants or inanimate objects.
- c - Mortality during hibernation.
 - (1) - Experimental studies continued.
 - (a) - Isolation of sample lots of infested material in locations representing different ecological influences, and varied conditions of exposure to temperature, moisture, shelter etc.
 - (2) - Field observations.
 - (a) - Continuation of incidental notes on percentage winter mortality during progress of all field work, under various conditions.
 - d - Study of influences affecting hibernation under controlled conditions.
 - e - Meteorological influences affecting hibernation.
 - (1) - Precipitation, temperature and the seasonal distribution of the same.
- 3 - Mortality.
- a - During hibernation. As in C-2-c.
- b - " remainder of the year. "
- c - " establishment of the young larvae.
 - (1) - Experimental studies continued.
 - (a) - Detailed observations concerning percentage of establishment of larvae from eggs deposited on various types, varieties and strains of corn and other plants, to determine possible relationship between larval mortality and different portions of selected host plant.
 - (b) - Relative mortality of young larvae hatching from eggs deposited upon a standard field corn variety planted on successive dates from early to late season.
 - (c) - Same as above on corn planted at various spacings.

- (d) - Same as above with standard non-susceptible field crops planted between rows of corn.
- (e) - Ability of larvae to hatch and reach plant from eggs dislodged from plants and falling to soil surface.
- (2) - Field observations.
 - (a) - Detailed observations similar to 3-c-(1) in commercial fields.
- d - Continuation of observations upon influences affecting mortality or survival of young larvae including meteorological, cultural etc.
- 4 - Tropic response in larval instars. (as a portion of studies detailed under D-4-a to c).
 - a - Laboratory experiments.
 - (1) - Identification of tropic reactions.
 - (2) - Sequence of tropic reactions.
 - (3) - Influence of response complex phenomena on tropic reactions.
 - (4) - Measurement of repellent and attractant values in response phenomena.
 - b - Field Experiments.
 - (1) - Relation of response to planting method.
 - (2) - Relation of response to insecticide application.
- D - Habits (Adults)
 - 1 - Selection of plants for oviposition.
 - 2 - Continuation of studies relative to oviposition habits of adults as affected by meteorological conditions.
 - 3 - Continuation of studies relative to natural dispersion as affected by wind movement.
 - 4 - Tropic response (in cooperation with Boyce-Thompson Institute)
 - a - Chemotropic response in adult female.
 - (1) - Value of attractant substances.
 - (a) - Production of volatile extractive constituents of corn, hops, etc.
 - (11) - Extraction at Boyce Thompson Institute.
 - (22) - Sealed, numbered and shipped.
 - (b) - Chemotropic tests at Arlington.
 - (11) - Tested for attractant value.
 - (22) - Modified olfactometer employed under controlled conditions.
 - (33) - Field tests employing traps.
 - (c) - Relation of attractant capacity to practicable application.
 - (2) - Value of repellent substances.
 - (a) - Production.
 - (b) - Chemotropic tests.
 - (c) - Relation to practicable application.
 - b - Relation of chemotropism to the normal complex of the European corn borer.
 - (1) - Investigation of the identity of the chemotropic response.
 - (a) - Separation of a feeding response.
 - (b) - Separation of a flight response.
 - (c) - Separation of a mating response.
 - (d) - Separation of an oviposition response.
 - (2) - Investigation of the response complex causing the induction



of chemotropism.

- (a) - Influence of the oviposition response on the development of chemotropism.
- (b) - Influence of chemotropism on the development of an oviposition reaction.
- (c) - Same study of other angles of this problem.
- (3) - Influence of a tropic reaction on the development of a chemotropic threshold.
 - (a) Effect of a phototropic reaction on chemotropic response.
 - (b) Same type of study of other tropisms.
 - (c) Sequence of reactions initiating a chemotropic response.
 - (d) The ecological complex in which chemotropism is most acute.

c - Field investigations of attrahent and repellent substances.

- (1) - Physical state of materials.
 - (a) - As a volatilizing concentrated liquid.
 - (b) - Diluted.
 - (11) - Tests of diluents, solvents, and adsorptives.
 - (22) - Supplemental carriers and adhesives.
 - (c) - Emulsified.
 - (d) - Influence and exploitation thermal and hygrostatic air conditions.
- (2) - Field trap experiments attrahent baits.
 - (a) - Effect of an ecological complex on the efficiency of a trap.
 - (b) - Coefficient of correlation for bait-trap field work.
 - (c) - Correlation of chemotropism and infestation of planted corn.
 - (d) - Relation of rate of infestation of crops to various environmental factors by making use of baited traps.
 - (e) - Investigation of corn-borer population with reference to climatic and ecological complexion of the area.

IV - Dispersion

- A - Flight - Continuation of studies as indicated under III-D-3.
- B - Relationship of artificial and common carrier to dispersion.
- 1 - Continuation of investigations relative to transportation of eggs, larvae, pupae or adults in commercial products.
- C - Relationship of water-drift to dispersion of host plants or waste commercial residues.
- 1 - Continuation of investigations relative to water-drift of infested material in lakes, rivers, etc.
- D - Dispersion as indicated by status of infestation.
- 1 - Continuation of field surveys in selected, representative townships in older portions of each infested area (New England, eastern New York, western New York, Ohio-Michigan). Such surveys to be made in same or nearby fields each year. Standard method of examination in each field.
- 2 - Same as above to include entire infested area, on basis of 5 fields per township. Method of taking data same as in D-1.
- 3 - Continuation of field infestation surveys (New England) in fields of economic hosts other than corn.

- 4 - Continuation of special field survey in New England in commercial sweet corn fields.
- 5 - Continuation of special field infestation surveys in susceptible weed hosts.
- 6 - Special pre-cleanup survey in stalk and stubble fields in infested areas of Middle West, to determine borer population before clean-up. Ten fields per township. Standard field count method used.
- 7 - Classification of infested areas according to intensity and character of infestation, with special reference to comparative infestation in corn and in other host plants and the size of area involved in each class. Applies to Middle West and New England areas.
- 8 - Continuation of statistical studies to determine probable errors involved in infestation surveys, and other surveys. Also studies to determine adequate sample limitations in such work.
- 9 - Indirect injury and commercial loss to corn and other crops.
 - a - Analysis of above surveys to compute probable economic losses suffered.
 - b - Detailed experimental studies and field observations to determine definite relationship between larval population and indirect injury, as the factor of principal importance in economic loss caused by corn-borer.

V - Host Plants

- A - Continue list of all economic and non-economic plants found infested. List arranged alphabetically and systematically.
 - 1 - Host plants classified according to
 - a - Relative susceptibility.
 - b - Nature of infestation.
 - c - Frequency of occurrence.
 - d - Stages of insect involved. (Generation in New England)
 - e - Portion of plant attacked.
 - f - Designate status of plant, for food or for shelter, or both.
 - 2 - Secure authentic identification of each new host plant and of insect found therein.
 - 3 - Continued investigations relating to suspected host plants.
 - 4 - Continued studies of plants exhibiting toxic or repellent qualities, to corn borer.
 - 5 - Continuation of isolation cages containing certain host plants infested by *P. nubilalis* to determine ultimate effect upon host plants other than corn, on the insect and whether host plant races exist. Also whether the species could exist for an indefinite period in the absence of corn.
- B - Exhibit material.
 - 1 - Herbarium of all host plants, including summer and winter condition (seeds, fruit, etc.).
 - 2 - Jars of preserved specimens, showing typical infestation in each plant species.



- 3 - Photos of plants, or portions thereof, showing typical infestations.
- 4 - Preparation of large and small Riker mounts and other exhibition sets.
- C - Seasonal abundance of the insect in each of the more important host plants according to
 - 1 - Condition of plant
 - 2 - Durability of plant for protection.
 - 3 - Due to abandonment of plant for new food supply.
 - 4 - Due to occurrence of first and second generation (New England).
- D - Portions of plant attacked as related to seasonal growth of plant and the seasonal development of insect.
- E - Duration, extent, nature and appearance of infestation.
- F - Proportion of plants attacked in heavy, medium and lightly infested areas.
- G - Relationship of certain plants to vitality and future development of insect.
 - a - Directly.
 - b - At end of several generations (as indicated under V-A-5.)
- H - Examine all plants suspected of functioning as host plants.

VI - Investigations In Europe.

- A - Distribution.
 - 1 - Continued checking of recorded distribution in Hungary, Yugoslavia, Roumania, Poland, Czechoslovakia, and Germany with extended scouting and study in Roumania and Poland. May be limited to scouting in northern Poland and into Lithuania and Esthonia. Preliminary scouting of important areas in Russia, if arrangements can be made to that end.
- B - Seasonal History.
 - 1 - Continued collection of data in Hungary, Yugoslavia, Roumania, Czechoslovakia, Germany and Poland. The most detailed information will be collected in Hungary and Yugoslavia.
 - a - Seasonal history data will be collected in Hungary and Yugoslavia during the course of the field work from May until October, throughout the main corn growing regions. The progress of pupation and emergence will be determined during the course of dissecting 1927 cornstalks. Egg counts will be started in the field as soon as possible and continued throughout the period of oviposition, and frequent observations will be made to determine the actual length of time that eggs may be found in the field. From the time that larvae are available in the field, systematic collections will be made of all the specimens found, thus offering a means for not only determining the percentage of individuals in each stage, but also the percentage of parasitism. Towns will be selected in the Danube Basin representing special environmental differences. Special collections and field studies will be made at these points.
 - b - Data will also be collected to show the transitions zones between areas of one and two-generation seasonal history.
 - 1 - An attempt will be made to secure information from the

merging of the two-generation area of the Dalmatian Coast into the one-generation area of Yugoslavia. If time is available, the merging of the two areas will also be studied in the vicinity of Skoplje to Nis, Yugoslavia.

2 - In any area visited particular attention will be paid to the collection of such information as might lead to a knowledge concerning the reactions of the insect to certain distinct types of environment.

C - Abundance and Damage - (Continuation of preceding 4 year period)

- 1 - A thorough study of this point continued throughout the Central European Plains, at points covering all ecological differences.
 - a - The collection of this data will include all those points mentioned in the main plan of work.
 - b - Data upon the infestation in other economic crops than corn.
 - c - Similar observations will be made to determine the infestation in such plants as related to heavily infested corn.
 - d - Observations to be made upon the infestation in weeds following a similar plan.

D - The determination of economic and non-economic host plants.

E - Parasites (continuation of preceding 4 year period)

- 1 - The effectiveness of the different species of parasites will be studied by means of the various dissections made during the course of the field work. To follow plans already made and carried out during the past seasons' investigations.
- 2 - Special studies in cooperation with Parasite section.

F - Natural Enemies other than parasites.

G - Control (continuation of preceding 4 year period)

- 1 - The effectiveness of control, particularly clean-up, will be measured by an examination of the debris remaining in fields after crops have been harvested and prepared for new sowings. Procedure same as in U. S.
- 2 - A study of the other control measures practiced.
 - a - Analyze the effectiveness of the various planting dates from collected field data.
 - b - Same procedure for other economic crops.

H - The collection of meteorological records with special emphasis upon those needed for the proper interpretation and correlation of biological data (continuation of preceding 4 year period).

- 1 - Continue the collection of agricultural records with special emphasis upon those relating to cultural methods, crop rotations, phenology, associated insects, etc., needed for the proper interpretation of the ecological facts concerning the insect. In addition to these enumerated points it is hoped to continue the investigation of the possibility of substituting various species of sorghums for corn, as a fodder plant, in regions of heavy infestation. For this purpose, plantings of five important species of sorghums, selected by the Arlington laboratory, will be planted in each of five selected localities in the Central European Plains to determine the susceptibility of these plants to the attack of the insect. This cultural experiment should be continued for at least five years.



VII - Investigations In The Orient (in cooperation with Japanese Beetle Investigations)

A - Continuation of present investigations with same general plan as outlined under VI.

- 1 - Biological observations.
- 2 - Economic "
- 3 - Ecological "
- 4 - Parasites and other natural enemies.
 - a - Shipment to the U. S. of those species which investigation may demonstrate as suitable for trial.

VIII - Natural Enemies

A - Parasites (Investigations in U. S.)

- 1 - Foreign.
 - a - Continued importation of desirable species from Europe (See VIII-B).
 - (1) - Continued investigations relative to best storage conditions.
 - b - Continued liberation of all adults not required for laboratory breeding, in areas infested by the corn borer.
 - (1) - New England (2)-New York (3)-Pennsylvania (4)-Ohio (5)-Michigan (6)-Indiana (7)-Illinois.
 - (a) - Special precautions to prevent escape of hyperparasites.
 - (b) - Special precautions to insure mating of sexes before liberation.
 - c - Continue allotment of quota of material to cooperators at Canadian Parasite Laboratory (Chatham, Ontario), for liberation in *contigucus* corn-borer-infested area of Ontario.
 - d - Continuation of large-scale breeding campaign in the laboratory with all such parasite species, for which a satisfactory breeding technique has been developed.
 - (1) - Liberation of such material in areas indicated in A-1-b.
 - e - Development of rearing technique, of certain species not yet solved, through a critical, practical study of their biology.
 - f - Perfection and improvement of existing breeding methods, to increase efficiency and economy.
 - g - Continuation of projects for recovery of imported species, in all areas, with special reference to direction and velocity of dispersion of such species.
 - (1) - Bulk collections of infested cornstalks, and other plants, placed in large screened cages. Includes large Parasite Conservation cages.
 - (2) - Systematic collections of host larvae, isolated for more accurate knowledge of percentage of parasitism, host relationship, velocity and direction of dispersion, etc., etc.
 - h - Continuation of life-history, seasonal occurrence, habits and other important biological reactions of each species of the imported parasites.
 - i - Continuation of the studies to ascertain reaction of imported parasites, and their survival, to various common control practices directed against corn borer in America. Particularly

to plowing, burning, disk ing and various rotations.

2 - Native parasites.

a - Continuation of observations and comparisons re native species.

(1) - Special collection of host eggs to determine effectiveness of T. minutum.

(2) - Same for larval and pupal parasites.

(3) - Special studies to determine whether native parasites are increasing their effectiveness as natural enemies of the borer, with special reference to comparisons of their status under various natural environmental and cultural conditions.

b - Laboratory breeding of T. minutum.

(1) - Test rearings and field liberations, followed by systematic collections, to determine feasibility of project.

(2) - Determine costs and economic possibilities of yearly liberations as a supplementary control measure.

c - Taxonomic and morphological studies of reared material.

(1) - Systematic grouping of reared specimens.

(2) - Study of morphological characters to aid in their identification and separation from imported European species.

(3) - Photographic study following method recently perfected.

(4) - Preparation for reference to group specialists in U. S. National Museum, or elsewhere.

d - Continuation studies of native, or introduced parasites, attacking other boring insects which are, or may later, become parasitic upon corn borer. To aid in the identification and separation of various developmental stages of parasites found attacking P. nubilalis.

e - Continuation of critical studies re the status and abundance of native parasites recovered from large Parasite Conservation cages, with proper allowance for their assignment to the proper host, as determined by isolated, individual rearings. Special attention to comparative status of each native species from year to year, as a natural enemy of P. nubilalis.

B - Parasites (Investigations in Europe)

1 - Continuation of collection of material for study

a - Parasite cocoons or puparia

(1) - Study of species hibernating as above.

(2) - Biology, hyperparasites, interrelations, economic status etc., etc.

b - Host larvae and pupae.

(1) - Dissections of larvae from various areas.

(a) - Study of species present, their determination, relationship etc.

(b) - Optimum areas of parasitism determined as above.

(2) - Adult parasites reared from above studied as in 1-a-(1) and (2).



- 2 - Continuation of collection of material for shipment to Arlington, Mass. laboratory.
 - a - Collected from most suitable areas as indicated from dissections.
 - b - Establishment of collectors in such areas.
 - c - Selection of local sites for collections.
- 3 - Method of sending material to Arlington, Mass.
 - a - Cocoon or puparia shipments.
 - b - Host larvae, containing internal parasites, shipment.
 - c - Summer collections handled similar to above.
- 4 - Study of conditions in different areas under observation.
 - a - Biology of host.
 - b - Host plants.
 - c - Reaction to ecological conditions.
 - d - Reaction to widely different types of agriculture.
 - e - Control methods observed and their value.
- 5 - Cooperation with K. W. Babcock and assistants as indicated under Section VI.
- 6 - Miscellaneous cooperation re parasites of alfalfa weevil, elm-leaf beetle and European earwig.
- C - Parasites (Investigations in Orient).
 - 1 - Procedure indicated under section VII.
 - 2 - Continuation of parasite shipments according to results of investigations to determine species present in the Orient, their biology interrelationships, economic status, etc.

Preliminary shipments received late in season of 1926.
- D - Predators.
 - 1 - Insects, 2 - Spiders. 3 - Birds. 4 - Animals.
 - a - Continuation of studies relating to the economic status of each of the above as natural enemies of the corn borer.

IX - Disease.

- A - Casual observations re death of larvae from disease.
 - 1 - In the field. 2 - In rearing cages.
 - a - Refer such specimens to specialists for determination.

X - Miscellaneous.

- A - Laboratory Methods and Technique.
 - 1 - Continuation of studies to develop rearing cages, for eggs, larvae, pupae and adults.
 - 2 - Incubators and other conditioning apparatus.
 - 3 - Large field cages for transfer experiments.
- B - Taxonomy and Exhibition.
 - 1 - Preparation and preservation of material for exhibition or study.
 - a - All stages of the corn borer and associated insects.
 - b - Typical samples illustrating injury to host plants.
 - 2 - Preparation of exhibit cases, Riker mounts, etc., as indicated under B-1.
 - 3 - Arrangement and care of working collection.
 - a - Corn borer and associated insects of the group.
 - b - Parasites.
- C - Statistics.



1 - Crop losses.

 a - Corn.

 b - Other economic crops attacked.

2 - Corn acreages and value of crops.

3 - Weather reports and other meteorological data.

4 - Maps.

D - Photography - including Motion Pictures.

 A - Photographs of

 1 - Apparatus and experimental equipment.

 2 - Drawings, maps, charts, signs, etc.

 3 - Infested plants, and portions thereof, showing typical
 injury and life stages in situ.

 4 - Parasites and technique employed..

 5 - Associated insects and their typical work.

 6 - Control operations, including operation of various equip-
 ment, results of such operation, educational photos showing
 satisfactory and unsatisfactory methods, etc., etc.



- 19 -

BUREAU OF PUBLIC ROADS

BUREAU OF PUBLIC ROADS

AGRICULTURAL ENGINEERING

A. Burning -

1. Development of mobile burner and testing
2. Trash burner or incinerator (See California trash burner)
3. Fundamental burner investigation
 - (In cooperation with entomologist)
 - Temperature and length of exposure for mortality of borer;
 - (a) Free
 - (b) In stalks in various conditions
 - (c) Alternation hot and cold (below freezing)
4. Testing other burners and other burning methods

B. Soil working -

1. Effectiveness of covering of corn stubble and standing stalks, by plowing with different width of plows, using different attachments and with and without various methods of treatment previous to plowing. Rotary hoe and rotary plow.
(Plowing treatment includes single discing, double discing, poling, rolling, cultipacking, etc.)
2. Effectiveness of discing or cultipacking on killing of borers.
(This question has often been raised but no definite figures are available.)
3. Effectiveness of above (1) and (2) operations in spring and fall.

C. Crop remnant cleaning.

1. Detaching stalks
 - (a) Poling (f)
 - (b) Mowing (g)
 - (c) Scraping
 - (d) Dragging
 - (e) Stubble shaver
2. Collecting stalks.

- (a) Dump rake (with different adjustments,
- (b) Side delivery (attachments, and reconstructed)
- (c) Sweepers
- (d) Hayloaders
- (e) Suction picker
- (f) Spike tooth picker

Some of this work will be done in the south during January and February in order to expedite progress.

D. Field machinery

1. Ensilage cutters

- (a) Field
- (b) Stationary

2. Combination picker shredder

3. Husker shredder

4. Baler attachments for above machine

5. Stubble pulverizer

6. Hand cutting tools

7. Low cutting binder attachment

8. Slitter attachment for binder

E. Electrical

1. Row machine

2. Violet, roentgen and other rays

Different colored lights

 " ray lengths

Some phase of this program will be undertaken in cooperation with the Bureau of Entomology, the Bureau of Agricultural Economics and with State Agricultural Experiment Stations.

BUREAU OF PLANT INDUSTRY.

BUREAU OF PLANT INDUSTRY

AGRONOMIC RESEARCH, CEREAL CROPS AND DISEASES

A. Investigations in heavily infested areas (Cooperative with the Bureau of Entomology and the Ohio Agricultural Experiment Station. Calendar year 1928).

1. Varietal trials, combined with rate and date of planting, cultural, and fertilizer experiments.
 - a. Different varieties planted at different dates and different rates to determine the relative yields of sound corn and the degree of infestation and damage by the corn borer.
 - b. Studies of the effects of different fertilizers applied in different ways, and of various cultural practices, upon the rate of development, yield of corn, and damage by the corn borer when different varieties of corn are planted on different dates.
2. Breeding experiments.
 - a. Isolation of selfed lines of corn and testing crosses between them for yield and for resistance or tolerance to the corn borer.
 - b. Breeding corn for productiveness when planted at an abnormal time to escape the heaviest attack of the corn borer.
3. Studies on the escapement from and tolerance to corn borer attack in relation to the condition and character of corn plants as determined by time, environmental and hereditary factors.
4. Research on the physiology of the corn plant with special reference to those processes, of which acceleration, retardation or modification may be effected to modify infestation or damage by the corn borer.

B. Investigations in lightly or noninfested areas (Cooperative with various State experiment stations, Fiscal year, 1929).

1. Varietal trials, combined with rate and date of planting and cultural and fertilizer experiments to determine the possibility of modifying present practices with the advent of the borer.
2. Breeding experiments to develop corn that will be productive when planted at an abnormal time.

AGRONOMIC RESEARCH, FORAGE CROPS

The Forage Crop program consists of two projects:

(1) Soybeans in the Corn Borer Area. It is proposed to appoint an assistant agronomist and to provide the necessary working material in order to study the production of soybeans, especially from two points of view, - (a) the development of a high oil-yielding and high-producing variety of soybean, and (b) the development of one containing a low percentage of oil. The point of view under (a) is to use the soybean as a cash crop, to be grown where the production of corn is unprofitable. It is contemplated that a study will also be made of the by-products of the oil industry. Under (b) an attempt will be made to produce a soybean with a low oil content, or, if this should not prove feasible, to combine this study with that of a study of the by-products of the soybean oil industry.

(2) The Study of Pasture Improvement in the Corn Borer Area. Experimental work on the improvement of pastures by the use of fertilizers, by treatments of other kinds, by reseeding, or by the use of species of pasture plants not now in common use in that territory. The work will be done in cooperation with an experiment station located in the corn borer territory, and cooperative arrangements will be made with the Bureau of Animal Industry and possibly with the Bureau of Dairying, in order that the best information of the Department will be brought to bear upon the problem involved.



BUREAU OF ANIMAL INDUSTRY, ANIMAL HUSBANDRY RESEARCH

A Study of Adjustments in Livestock Production Practices made necessary by the advent of the European Corn Borer.

To make a study of livestock production practices in the region, infested with the European corn borer, and nearby areas, for the purpose of ascertaining the methods of breeding, feeding and management of domestic farm animals including poultry, which will enable the farmer to operate most profitably under the new conditions.

Survey the influence which the control measures and the decreased production of corn is having upon the methods of producing livestock in that area.

Determine what changed practices have been successfully used by farmers in this territory.

Ascertain what additional practices can be adopted based upon the results of scientific information obtained by the various State experiment stations and other research agencies.

Special research for the development of new facts concerning the utilization of substitute crops and pastures based on the needs of the situation as brought out by the above determinations.

Cooperation of the Bureaus of Animal Industry, Plant Industry and Agricultural Economics of the Department, and the Experiment Stations, Colleges of Agriculture and other interested agencies in the areas menaced by the European corn borer.



BUREAU OF CHEMISTRY AND SOILS.



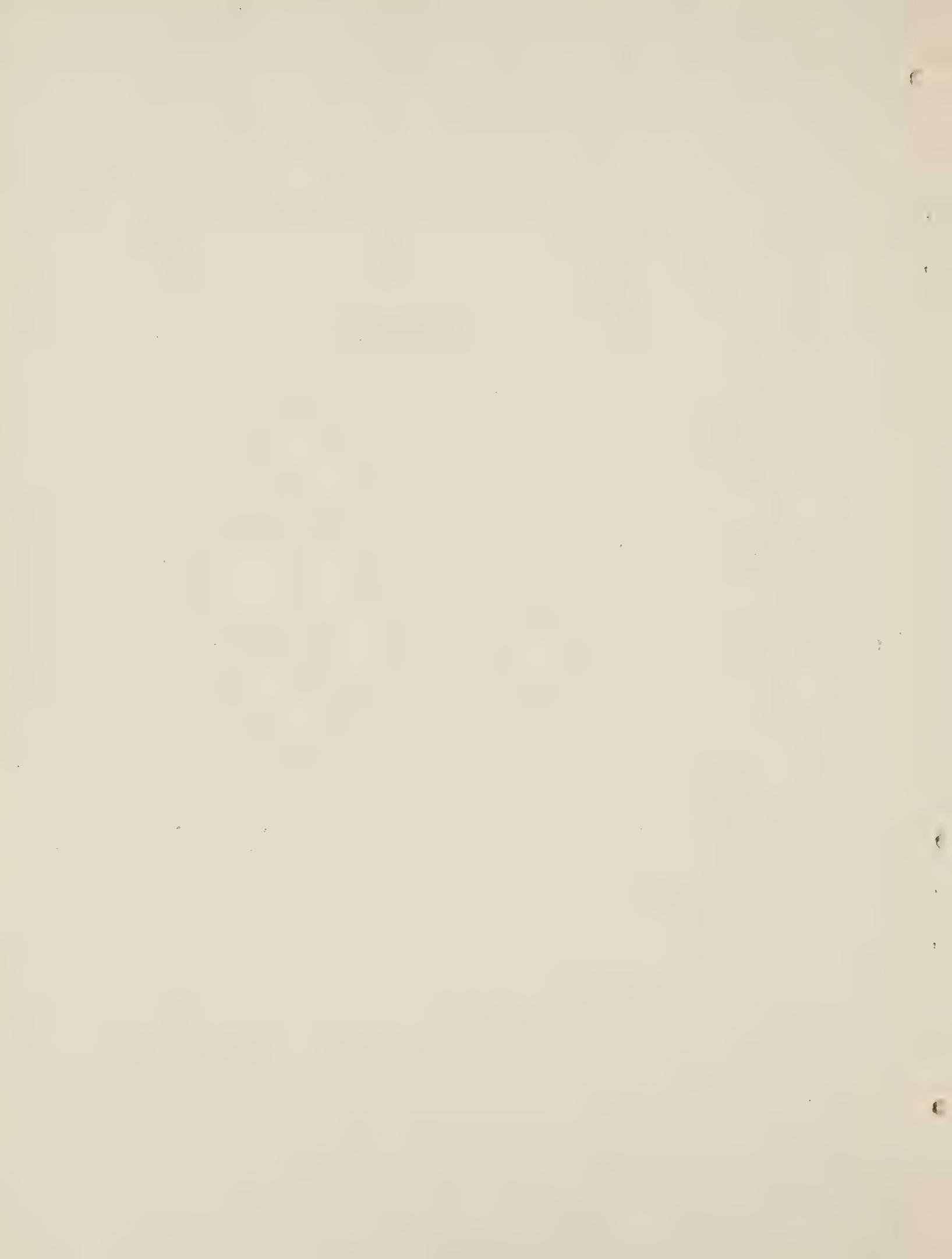
BUREAU OF CHEMISTRY AND SOILS

INSECTICIDES

1. Chemical analysis of insecticides used by the Bureau of Entomology in its various laboratory and field tests.
2. The determination of the solubility, rate of solution, crystal size, apparent density, and other physical properties of insecticides being tested by the Bureau of Entomology.
3. The synthesis of new insecticides to be tested by the Bureau of Entomology.

SOILS

Mapping of the soil in the regions infested by the European corn borer, in order to determine whether there is correlation between the character of the soil with its accompanying flora, and the intensity of infestation by the insect.



BUREAU OF AGRICULTURAL ECONOMICS.



AGRICULTURAL ECONOMICS

Studies relating to the Corn Borer to be Made by the Bureau of Agricultural Economics.

1. Analysis of types of farming in the corn borer areas of the eastern Corn Belt. Available data from the Census, Crop Estimates and other sources will be analyzed and used in delineating areas within which different types of farming prevail. Special tabulations of census data are being made for selected localities in the region so as to determine the relative importance of corn on farms of different types and sizes and the systems of farming which are most common in each area. This basic picture of systems of farming in each area will be used as a point of departure in subsequent farm management and cost studies relating to the adjustments in farm practices and farming systems made necessary by the corn borer.

In cooperation with the State Experiment Stations.

2. Collection of data as to present methods of harvesting corn and disposing of the stalks in the infested areas and those likely to be infested soon. Data will be assembled and maps made showing the proportion of the corn acreage harvested by different methods such as cutting, shredding, ensiling, hogged down and husking from standing stalks, the height of the stubble left where corn is cut and the methods used in disposing of stalks or stubble.



3. A study of the requirements and costs of using the husker-shredder and the use of shredded stover in feeding livestock. The requirements and costs of using the husker-shredder as compared with other methods of husking corn and feeding stover will be determined. The feeding value of shredded stover as compared with stover not shredded and the storage and utilization of shredded stover on farms where shredding is a common practice will also be considered.

This work will be done in cooperation with the Division of Agricultural Engineering of the Bureau of Public Roads, the Division of Animal Husbandry of the Bureau of Animal Industry and State Experiment Stations.

4. A study of the labor and power required by the various control methods used in the 1927-28 season. Data will be obtained from typical localities in all important sections of the infested area in the eastern Corn Belt and analyzed so as to determine the methods of control which are most economical for particular circumstances under actual farm conditions.

To be done in cooperation with the Experiment Stations.

5. A detailed study in one area to determine the conditions with respect to (a) possible damage by the borer and reduction in the yield of corn; (b) labor and power for growing corn under corn borer conditions; (c) possible reduction in yields of other crops because of delayed seeding or changes in methods of preparing the land and (d) relative prices for corn and other crops under which it will be advantageous for farmers to substitute other crops for all or a part of the corn acreage. Some phases of this study will be undertaken jointly with the Division of Agricultural Engineering, Bureau of Animal Industry and Bureau of Plant Industry.

